

**SOLUBLE FERTILIZER COMPOSITIONS COMPRISING CALCIUM
AND/OR MAGNESIUM PHOSPHATES**

Field of the Invention

5 The present invention relates to solid, highly soluble fertilizer compositions, comprising Monobasic Calcium Phosphate (MCP) and/or Monobasic Magnesium Phosphate (MMgP), together with alkali metal double phosphates, which compositions are solid, freely flowing and highly soluble, and to a method for preparing said compositions.

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Background of the Invention

Monobasic Calcium Phosphate (MCP) $\text{Ca}(\text{H}_2\text{PO}_4)_2$ and Monobasic Magnesium Phosphate (MMgP) $\text{Mg}(\text{H}_2\text{PO}_4)_2$ are widely used as fertilizers. They have the drawback of being only slightly soluble in water, whereas such
15 fertilizers are usually applied in aqueous solutions. However, solubility, while essential, is not the only property required. Fertilizers must be packed, shipped and handled, and therefore must have appropriate physical properties, viz. must be adapted to form granules or powders that are free flowing, have low hygroscopicity, do not tend to agglomerate, and so forth.
20 The art does not provide such fertilizers or their formulations having such optimal physical characteristics, in addition to high solubility.

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It is therefore the purpose of this invention to provide compositions, comprising MCP and/or MMgP, that have such desirable physical properties.

It is another purpose of this invention to provide such compositions that are suitable for use as components of food and/or drinks.

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It is a further purpose to obtain such compositions in crystalline and homogeneous form.

It is a further purpose to obtain such compositions which contain other fertilizer compounds, preferably potassium compounds.

It is a further purpose to provide formulations from which such compositions
5 are obtained and a process for obtaining said compositions from said formulations.

Summary of the Invention

The present invention, in one of its aspects, provides fertilizers formulations
10 comprising the following components: 1) at least one monobasic earth-alkali metal phosphate, chosen from among Calcium Phosphate (MCP) $\text{Ca}(\text{H}_2\text{PO}_4)_2$, Magnesium Phosphate (MMgP) $\text{Mg}(\text{H}_2\text{PO}_4)_2$, or mixtures thereof; 2) at least one alkali metal phosphate; and 3) Phosphoric Acid (PA) H_3PO_4 . The alkali metal phosphate will be generally indicated hereinafter by MALP, and is
15 preferably Monopotassium Phosphate (MKP) KH_2PO_4 . The term "alkali metal", as used herein, should be construed as including NH_4 .

The said formulations, as such, are an object of the invention. However, also according to the invention, they are subjected to a homogenizing, drying and
20 heating processing, from which are obtained fertilizer compositions that can be stored, shipped and used for making aqueous solutions, said solution being applied to the areas to be fertilized. During the processing the alkali metal phosphate MALP reacts with PA to form a double salt, that will be indicated as $\text{AH}_5(\text{PO}_4)_2$ or, shortly, HAP, and is $\text{KH}_5(\text{PO}_4)_2$ if the alkali metal
25 is potassium. In order to distinguish from the original mixture, which contains an alkali metal phosphate MALP and H_3PO_4 , and the processed material, which contains the double salt HAP and, optionally, an amount of MALP, the original mixture will be called hereinafter "fertilizer formulation" and the processed material will be called hereinafter "fertilizer composition".

The required amounts of the above components in the formulations are given hereinafter. Said amounts must satisfy the following conditions:

- a) MALP (preferably MKP) is in a molar ratio to PA that is at least the ratio corresponding to the alkali metal double salt $\text{AH}_5(\text{PO}_4)$ (HAP). However, there may be a moderate excess of MALP over said ratio, viz. the ratio $\text{A}_2\text{O}:\text{P}_2\text{O}_5$ (preferably $\text{K}_2\text{O}:\text{P}_2\text{O}_5$), wherein the P_2O_5 does not comprise that included in phosphate moieties of the earth-alkali metal phosphates, must be from about 0.5 to about 0.8. Small departures from said limits may also be acceptable.
 - b) The molar ratio of CaO and/or MgO to $\text{P}_2\text{O}_5\text{T}$, wherein $\text{P}_2\text{O}_5\text{T}$ comprises the total amount of P_2O_5 included in the formulations, is: A) from 1:4.5 to 1:15.1, typically 1:4.8, if the earth-alkali metal is calcium; B) from 1:3.3 to 1:7.5, typically 1:3.8, if the earth-alkali metal is magnesium.
- The compositions, after processing, comprise therefore MCP or MMgP and HAP, and may comprise an amount of MALP. The molar ratios of said components depend on the molar ratios of the formulations from which they derive. The molar ratio of CaO and/or MgO to P_2O_5 is the same as in the corresponding formulation. The molar ratio of MALP to HAP is from zero to 60%. Small departures from said limits may also be acceptable. Of course, additional components may be present to supply additional fertilizer moieties or for other purposes known in the fertilizer art.

Another aspect of the invention is a process for the preparation of the compositions of the invention from the corresponding formulations. Said process comprises the steps of preparing the formulation, preferably in the form of a watery paste; introducing said formulation into an drying oven of a material resistant to said components (particularly to the PA); and mechanically homogenizing the mixture, while concurrently drying it by heating under a vacuum.

If it is intended to use the product in food or drink, all the components must be of a quality certified for such a use.

5 The compositions can be dissolved in water at room temperature or above it, and form clear solutions. Their solubility varies from 10 to 40 % by weight, the higher solubilities being attained when the earth-alkali metal is magnesium. Solutions of 1 wt% of the above compositions have pH 2÷2.5.

10 The properties of the compositions in their solid, dry state are as follows: grain size of their granulates or powders $0.05 < \text{diameter} < 1.0$ mm; bulk density of the 0.5÷1.2; hygroscopicity 50÷70% C.R.H. (critical relative humidity); free flowability index, determined as described below, 40-70%.

15 The free flowing index is determined as follows. A funnel of stainless steel is used, having a smooth surface, a top diameter of 100 mm and a bottom diameter of 10 mm. 300 grams of the substance under examination are introduced into said funnel while keeping its bottom opening closed. Then the bottom opening is opened, the substance is allowed to flow into a receiving container, and the time required for it to flow completely through
20 the funnel is measured. The same measurement is carried out for a substance used as standard. The flowability index FI% is $FI\% = 100(t_0/t_1)$, wherein t_0 is the flow time measured for the standard substance and t_1 is the flow time measured for the substance under examination. In this application, the standard substance is MKP and t_0 is 16 seconds. It is clear
25 that the more quickly the substance under examination flows, the higher is its flowability index.

The compositions of the invention are crystalline. X-ray analysis shows two types of crystals: those of earth-alkali metal monophosphates $\text{Ca}(\text{H}_2\text{PO}_4)_2$
30 and/or $\text{Mg}(\text{H}_2\text{PO}_4)_2$ and crystals of AH_2PO_4 and $\text{AH}_5(\text{PO}_4)_2$, where A is the alkali metal.

The formulations can be ground, sieved and packed, e.g., in bags, for storage, transportation and selling to users, and they give clear aqueous solutions even close to or at saturation concentration.

5 Detailed Description of Preferred Examples

Ranges of optimal concentration ratios are given in Table I.

Table I

Optimal Ranges		Broad Ranges		Salt
CaO(MgO): A ₂ O	CaO(MgO): P ₂ O ₅ T	CaO(MgO): A ₂ O	CaO(MgO): P ₂ O ₅ T	
0.35 ÷ 0.66	0.14 ÷ 0.21	0.062 ÷ 0.74	0.032 ÷ 0.224	Ca(H ₂ PO ₄)
0.56 ÷ 1.76	0.19 ÷ 0.33	0.13 ÷ 2.12	0.075 ÷ 0.35	Mg(H ₂ PO ₄)

10 where A is either K, Na or NH₄.

In the Table P₂O₅T means total phosphoric anhydride, viz. the total amount of the P₂O₅ in the composition, comprising that which is part of the earth-alkali phosphates, the alkali phosphates and the phosphoric acid.

The following examples illustrate embodiments of the invention. The percentages are by weight.

20 Example 1

Into a drying oven, made of stainless steel and with a work volume of 6 liters, and provided with an agitator, the following chemicals were charged:

Phosphoric acid (P₂O₅ 67.5%) 3123.8 gr

MKP (KH₂PO₄) 1824 gr

25 Slurry of Magnesium hydroxide (Mg(OH)₂ 79.5%) 879.3 gr, and 1219 gr of water (35% solids).

During the charge of those chemicals, the agitator was operated at 50 rpm. Once the charge was completed, heating was begun by means of a heating jacket with circulation of hot oil having a temperature of 120°C. Subsequently a vacuum pump was actuated, gradually to avoid loss of material due to violent boiling since the vacuum may reach 50 mbar. Water was removed during two hours until the water content of the drier content was lowered to 0.36%. A powdery material is thus obtained, which is free-flowing and may be extracted and transferred to a storage vessel. A portion thereof remains in the oven, sticking to the agitator and the walls. The extracted powdery material has the granulometry shown in the following table, in which the first column indicates the weight percentage of the fractions the size range of which is indicated in the second column in millimeters.

	26.9	>4 mm
15	26.0	2-4 mm
	20.3	1-2 mm
	14.4	0.45-1 mm
	4.9	0.25-0.45 mm
	5.3	0.125-0.25 mm
20	2	<0.125 mm

The chemical analysis of the product indicates the following weight percentages:

P₂O₅ 59.6%, K₂O 11.3%, MgO 8.8%. Turbidity NTU 4.

The product further contains the following metals:

25	<10 ppm heavy metals
	10 ppm Zn
	0.4 ppm Pb
	0.46 ppm V
	1.3 ppm Mn
30	13 ppm Fe
	1 ppm Cu

0.2 ppm Cd

1.3 ppm As

The pH is 2.4

Flowability Test— 64%

5 Solubility at 20°C – 55%

Example 2

The drying oven used is the same as in Example 1. The materials charged into it are:

10 Phosphoric acid (P_2O_5 66.9%) 2239 gr

MKP (KH_2PO_4) (99.8%) 1330.8 gr

Slurry containing 488 gr of $Ca(OH)_2$ dry, and 905.7 gr of water.

During the charge of those chemicals, the agitator was operated at 50 rpm.

Once the charge was completed, heating was begun by means of a heating

15 jacket with circulation of hot oil having a temperature of 120°C.

Subsequently a vacuum pump was actuated, gradually to avoid loss of material due to violent boiling since the vacuum may reach 50 mbar. Water

was removed during two hours until the water content of the drier content

20 was lowered to 1.5%. A powdery material is thus obtained, which is free-flowing and may be extracted and transferred to a storage vessel. A portion thereof remains in the oven, sticking to the agitator and the walls. The

extracted powdery material has the granulometry shown in the following

table, in which the first column indicates the weight percentage of the

fractions the size range of which is indicated in the second column in

25 millimeters.

7.7	> 1 mm
6.8	0.425-1 mm
2.1	0.25-0.425 mm
2.3	0.125-0.25 mm
30 81.1	< 0.125 mm

The chemical analysis of the product indicates the following weight percentages: P_2O_5 57.1%, K_2O 11.4%, CaO 8.5%. Turbidity NTU 18. Flowability Test – 70%. Solubility at 20°C – 41.7%. C.R.H. – 70%.

The pH is 2.5.

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The product further contains the following metals:

10 ppm heavy metals

36 ppm Zn

0.26 ppm Pb

10 1.2 ppm V.

2 ppm Mn

28 ppm Fe

1.3 ppm Cu

0.2 ppm Cd

15 0 ppm As

Example 3

The drying oven used is the same as in Example 1. The materials charged into it are:

20 Phosphoric acid (P_2O_5 67.5%) 4733.1 gr

Sodium hydroxide (NaOH 47.7%) 1363.5 g

Slurry containing 878.75 gr of $Mg(OH)_2$ (79.5%) and 1117 gr of water.

During the charge of those chemicals, the agitator was operated at 50 rpm.

Once the charge was completed, heating was begun by means of a heating jacket with circulation of hot oil having a temperature of 120°C.

25 Subsequently a vacuum pump was actuated, gradually to avoid loss of material due to violent boiling since the vacuum may reach 50 mbar. Water was removed during two hours until the water content of the drier content was lowered to 1.1%. A powdery material is thus obtained, which is free-
30 flowing and may be extracted and transferred to a storage vessel. A portion thereof remains in the oven, sticking to the agitator and the walls. The

extracted powdery material has the granulometry shown in the following table, in which the first column indicates the weight percentage of the fractions the size range of which is indicated in the second column in millimeters.

5	13.1	>1 mm
	13.2	0.425-1 mm
	3.9	0.25-0.425 mm
	18.7	0.125-0.25 mm
	51.1	<0.125 mm

- 10 The chemical analysis of the product indicates the following weight percentages: P_2O_5 % 60.9%, Na_2O % 9.4%, MgO % 9.1%. Turbidity NTU 4. The pH is 3.0.

The product further contains the following metals:

	10	ppm heavy metals
15	21	ppm Zn
	0.9	ppm V
	1.7	ppm Mn
	22	ppm Fe
	0.32	ppm Pb
20	0.9	ppm Cu
	0.2	ppm Ca
	0	ppm As

Flowability – 42.1%. Solubility at 20°C – 51.9%. C.R.H. – 55%.

- 25 The above examples are intended to illustrate the invention and it is to be understood that the invention can be carried out with many modifications, adaptations and variations, without departing from its spirit or exceeding the scope of the claims.